

CLAIMS

1. An optical communications system, comprising:
a transmitter;
5 a receiver;
an optical communications link between the transmitter and receiver comprising a plurality of spans; and
at least one line amplifier between spans of the communications link,
wherein the receiver comprises:
10 optical to electrical conversion circuitry for converting the received optical signal to an electric signal;
analogue to digital conversion circuitry; and
digital signal processing means for analysing the electrical digital signal, wherein the digital signal processing means derives information concerning characteristics of individual
15 spans from the electrical digital signal.
2. A system as claimed in claim 1, wherein the means for analysing the electrical digital signal analyses a self phase modulation effect within the received signal.
- 20 3. A system as claimed in claim 2, wherein the means for analysing the electrical digital signal analyses a self phase modulation effect at installation of the system, or on an unused wavelength of a system which is in service.
4. A system as claimed in claim 2, wherein the means for analysing the electrical digital
25 signal analyses a self phase modulation effect in-service.
5. A system as claimed in claim 1, wherein the means for analysing the electrical digital signal analyses a cross phase modulation effect within the received signal.
- 30 6. A system as claimed in claim 5, wherein the means for analysing the electrical digital signal analyses a cross phase modulation effect at installation of the system in response to first and second test signals transmitted over different frequency channels.

7. A system as claimed in claim 5, wherein the means for analysing the electrical digital signal analyses a cross phase modulation effect in-service.

8. A system as claimed in claim 7, wherein the means for analysing the digital signal comprises:

means for correlating a cross talk signal based on a received signal with an interfering signal to derive a correlation signal.

9. A system as claimed in claim 8, wherein the means for analysing the digital signal comprises:

means for averaging the received signal or estimating the average received signal and deriving a complex conjugate thereof.

10. A system as claimed in claim 9, wherein the means for analysing the digital signal comprises:

means for multiplying an XPM component of the received signal with the complex conjugate of the averaged signal in order to derive the cross talk signal.

11. A system as claimed in claim 8, wherein the interfering signal comprises a data signal transmitted over a different channel to the analysed signal.

12. A system as claimed in claim 8, wherein the means for analysing the digital signal comprises:

means for filtering the correlation signal to remove a symbol rate component.

13. A system as claimed in claim 5, wherein the transmitter comprises means for adjusting the relative polarization states of first and second channels which interfere to produce the cross phase modulation.

14. A system as claimed in claim 13, wherein the digital signal processing means includes means for analysing electrical digital signals for different relative polarization states of the first and second channels.

15. A system as claimed in claim 1, wherein the means for analysing the electrical digital signal analyses a four wave mixing effect.

16. A system as claimed in claim 15, wherein the means for analysing the electrical digital signal analyses a four wave mixing response between pulsed waveforms.

17. A system as claimed in claim 15, wherein the means for analysing the electrical digital signal analyses a four wave mixing response between pulsed and continuous waveforms.

18. An optical communications system, comprising:
a transmitter;
a receiver; and
an optical communications link between the transmitter and receiver comprising a plurality of spans,

wherein the transmitter comprises means for modulating an optical signal for transmission using single side band modulation, wherein the modulating means is controllable to use upper side band modulation or lower side band modulation at different times as desired, and wherein the receiver comprises means for determining the differential delay between upper and lower side band modulations, thereby to determine the dispersion of the optical communications link.

19. A system as claimed in claim 18, wherein the receiver comprises:
optical to electrical conversion circuitry for converting the received optical signal to an electric signal;
analogue to digital conversion circuitry; and
digital signal processing means for determining the differential delay.

20. A system as claimed in claim 19, wherein the digital signal processing means determines the differential delay by cross correlating the received signal with the upper side band signal envelope and with the lower side band signal envelopes.

21. A transmitter for use in an optical communications system, comprising:

means for modulating an optical signal for transmission using single side band modulation, wherein the modulating means is controllable to use upper side band modulation or lower side band modulation at different times as desired.

- 5 22. A receiver for use in an optical communications system for receiving an optical signal from an optical link comprising a plurality of spans, the receiver comprising:
- optical to electrical conversion circuitry for converting a received optical signal to an electric signal;
 - 10 analogue to digital conversion circuitry; and
 - digital signal processing means for analysing the electrical digital signal, wherein the digital signal processing means derives information concerning characteristics of individual spans from the electrical digital signal.
- 15 23. A method of monitoring characteristics of an optical link in an optical communications system between a transmitter and a receiver, the method comprising:
- receiving a signal from the transmitter at the receiver;
 - converting the received optical signal to an electric signal;
 - performing analogue to digital conversion; and
 - 20 analysing the electrical digital signal to derive information concerning characteristics of individual spans from the electrical digital signal.
24. A method as claimed in claim 23, wherein analysing the electrical digital signal comprises analysing a self phase modulation effect within the received signal.
- 25 25. A method as claimed in claim 24, wherein analysing the electrical digital signal comprises analysing a self phase modulation effect at installation of the system.
26. A method as claimed in claim 24, wherein analysing the electrical digital signal comprises analysing a self phase modulation effect in-service.
- 30 27. A method as claimed in claim 23, wherein analysing the electrical digital signal comprises analysing a cross phase modulation effect within the received signal.

28. A method as claimed in claim 27, further comprising:
transmitting first and second test signals over different frequency channels at system
installation, and
wherein analysing the electrical digital signal comprises analysing a cross phase
5 modulation effect between the first and second test signals.
29. A method as claimed in claim 27, wherein analysing the electrical digital signal
comprises analysing a cross phase modulation effect in-service.
- 10 30. A method as claimed in claim 29, further comprising:
correlating a cross talk signal based on the received signal with an interfering signal to
derive a correlation signal.
31. A method as claimed in claim 30, wherein the interfering signal comprises a data signal
15 transmitted over a different channel to the analysed signal.
32. A method as claimed in claim 30, wherein analysing the digital signal comprises filtering
the correlation signal to remove a symbol rate component.
- 20 33. A method as claimed in claim 32, wherein analysing the digital signal comprises
averaging the received signal and deriving a complex conjugate of the averaged signal.
34. A method as claimed in claim 33, wherein analysing the digital signal comprises
multiplying an XPM component of the received signal with the complex conjugate of the
25 averaged signal in order to derive the cross talk signal.
35. A method as claimed in claim 27, further comprising adjusting the relative polarization
states of first and second channels which interfere to produce the cross phase modulation.
- 30 36. A method as claimed in claim 35, further comprising analysing electrical digital signals
for different relative polarization states of the first and second channels.

37. A method as claimed in claim 23, wherein analysing the electrical digital signal comprises analysing a four wave mixing effect.

38. A method of operating an optical communications system comprising a transmitter, a receiver and an optical communications link between the transmitter and receiver comprising a plurality of spans, the method comprising:

at the transmitter, modulating an optical signal for transmission using single side band modulation, using upper side band modulation and lower side band modulation at different times;

at the receiver, determining the differential delay between upper and lower side band modulations, thereby to determine the dispersion of the optical communications link.

39. A method as claimed in claim 36 wherein the rate of change with propagation distance of relative polarisation orientation between co-propagating signals is derived from the polarisation dependence of the magnitude of the XPM crosstalk induced at different locations in the fibre, thereby to determine the differential group delay or polarisation mode dispersion between said locations.

40. A method as claimed in claim 39 wherein the variation in signal power with polarisation orientation is derived, thereby to determine the polarisation-dependent loss between different locations in the fibre.

41. A computer program comprising code means for implementing a method of monitoring characteristics of an optical link in an optical communications system between a transmitter and a receiver, the code means comprising instructions for controlling the system to:

receive a signal from the transmitter at the receiver;

convert the received optical signal to an electric signal;

perform analogue to digital conversion; and

analyse the electrical digital signal to derive information concerning characteristics of individual spans from the electrical digital signal.

42. A computer program as claimed in claim 41, wherein the code means comprises instructions for controlling the system to analyse a self phase modulation effect within the

received signal in service or at installation of the system, and/or to analyse a cross phase modulation effect within the received signal.

43. A computer program comprising code means for implementing a method of operating an optical communications system comprising a transmitter, a receiver and an optical communications link between the transmitter and receiver comprising a plurality of spans, the code means comprising instructions for controlling the system to:
- 5 at the transmitter, modulate an optical signal for transmission using single side band modulation, using upper side band modulation and lower side band modulation at different times;
- 10 at the receiver, determine the differential delay between upper and lower side band modulations, thereby to determine the dispersion of the optical communications link.
44. A optical communications signal for transmission over an optical communications link, wherein the signal is modulated alternately with upper side band modulation and lower side band modulation, wherein the differential delay between the upper and lower side band modulations is
- 15 used to determine the dispersion of the optical communications link.